

ABBOTT LABORATORIES

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June 13, 2008

Mr. David Garrett  
Environmental Scientist  
RCRA Corrective Action and Permits Branch  
Air and Waste Management Division  
United States Environmental Protection Agency - Region 7  
901 N. 5<sup>th</sup> St.  
Kansas City, KS 66101

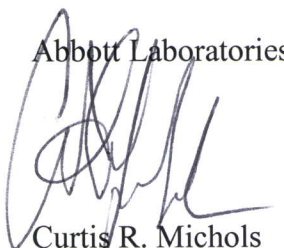
RE: Copy of April 14, 2008 Letter

Dear Mr. Garrett:

Per your request, enclosed is a copy of the above letter. Please let me know if you need anything else.

Best regards,

Abbott Laboratories



Curtis R. Michols  
Principal Specialist



4013

RCAP-RECEIVED

JUN 16 2008



ABBOTT LABORATORIES

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*Via express delivery*

April 14, 2008

Mr. Brad Roberts  
Professional Geologist  
Bureau of Waste Management  
Kansas Department of Health & Environment  
1000 SW Jackson, Suite 320  
Topeka, Kansas 66612-1366

Mr. David Garrett  
Project Manager  
RCRA Corrective Actions  
United States Environmental Protection Agency  
901 N. Fifth Street  
Kansas City, Kansas 66101

Re: Follow-Up on Action Items from  
February 5, 2008 Meeting regarding  
Former Evaporation Lagoon Closure and Corrective Measures Implementation  
Wichita, Kansas

Dear Messrs. Roberts and Garrett:

This letter provides follow-up on the action items we detailed in the minutes of our February 5, 2008 meeting at Brad's office. Each of the action items and follow-up (in italics) are as follows.

- Abbott to provide KDHE and US EPA a copy of the Operations & Maintenance (O&M) Plan prepared for the former evaporation lagoon cap. – *A copy of this plan (draft) is provided in Attachment 1. As this Plan is still draft, any review comments would be appreciated.*
- Abbott to confirm what breakdown data is available, evaluate, and propose an approach to address this. – *Breakdown information and breakdown product information that Abbott has been able to assemble is provided in Attachment 2. As indicated, the compounds listed are concluded to readily breakdown, but limited confirmation of breakdown products is available. Given the limited information available, Abbott will further evaluate and submit a more detailed response on analytical protocol to evaluate breakdown products.*
- Abbott to set up call to discuss groundwater modeling – *This call and discussion was held on February 29.*
- Abbott to review the well searches that have been done and report results back. – *Documentation of well searches conducted during RCRA Facility Investigation (RFI) activities and again recently in February 2008, and during re-permitting of a Class I Non-Hazardous Injection Well located at the site, is provided in Attachment 3. This documentation confirms Abbott's conclusions and assertion that there are no viable wells/receptors at risk.*

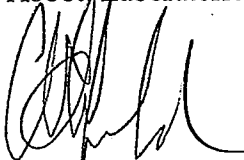
April 14, 2008

- Abbott to set up call to discuss development of site-specific risk-based cleanup objectives. – *This call and discussion was held on February 29.*
- Abbott to provide more definition on well locations and well profiles. – *Copies of highlighted portions of the RFI Report and associated cross-section figures detailing such information are provided in Attachment 4.*
- Abbott to provide revised data tables with analytical results and method detection levels (MDLs). – *These tables are provided in Attachment 5. Please note these are the same tables that were provided to both KDHE and EPA in the June 20, 2007 letter from Abbott to Bill Bider that provided additional clarification and detail on our proposed closure approach.*
- Abbott to provide revised CMI 2007 Annual Groundwater Monitoring and Progress Report map and report. – *A revised report with map is provided in Attachment 6.*
- Abbott to schedule date for site inspection. – *It has been confirmed that the date and time for the site inspection is April 16, 2008 at 9:00 am central standard time. Abbott, Matrix (Abbott's consultant) and KDHE are scheduled to be present. US EPA will not be present due to schedule conflict.*

Abbott looks forward to KDHE and US EPA's response to our proposed closure approach for both the former evaporation lagoon and the RCRA CMI at the site. Please let me know if you have any questions, concerns or comments on the attached, or need any further information.

Best regards,

Abbott Laboratories



Curtis R. Michols  
Principal Specialist  
Global Environment, Health, Safety & Energy

Enclosures

c.c.: L. Sneed, Abbott  
J. Thorsen, Matrix  
D. Lentz, ERM

**ATTACHMENT 1**

**DRAFT O&M PLAN**

# Abbott

*Former Abbott Property  
Wichita, Kansas*

## **OPERATION AND MAINTENANCE OF THE ENHANCED CAP AT THE FORMER EVAPORATION LAGOON**

*March 2008*

Prepared for:

Abbott  
200 Abbott Park Road  
Abbott Park, Illinois 60064

Prepared by



**MATRIX ENVIRONMENTAL, INC.**  
1880 W. Winchester Avenue, Suite 111  
Libertyville, Illinois 60048

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## SECTION 1

### EXECUTIVE SUMMARY

Matrix Environmental, Inc. (Matrix) was retained by Abbott to construct an enhanced engineered cap for the former evaporation lagoon located at the former Abbott facility in Wichita, Kansas. The goal of the project was to improve the effectiveness of the existing cap with the ultimate goal of abandoning the existing leachate collection system and in turn abandoning the deep underground injection well. In addition, the engineered cap will prevent the infiltration of water and the production of leachate and potential impact to groundwater.

This document is the Operation and Maintenance Plan for the monitoring and maintenance period and it identifies the actions necessary to attain the goal of this enhanced cap as stated above.



## SECTION 2

### SITE DESCRIPTION

The former Abbott facility commenced operations at the site in 1960. The operations originally included the production of cyclohexylamine used in the production of an artificial sweetener. Facility operations later included the production of amine-based intermediate products that were used in the production of textiles, rubber, plastics, adhesives and pharmaceuticals.

Abbott sold the facility to Air Products and Chemicals, Inc. in 1985, but retained ownership of Solid Waste Evaporation Lagoon, as well as the evaporation pond, drum storage area and injection well. The lagoon was constructed in 1980. Operation of the evaporation lagoon system was managed essentially as a "closed loop" treatment system. That is, a thin layer of wastewater was allowed to evaporate. Unevaporated wastewater gradually infiltrated through the liner and accumulated in the leachate collection system sump. Periodically the contents of this sump were pumped back into the lagoon and the evaporation/collection cycle continued.

Abbott began closing the evaporation lagoon after it ceased operations at the property in 1985. The closure activities were approved by KDHE. In May 1986, the remaining contents of the evaporation lagoon were emptied and disposed of on-site into the deep injection well.

Although the former evaporation lagoon is technically closed, the leachate collection system continues to operate and the collected effluent is disposed via injection into the onsite injection well. The 7 January 1987 KDHE Closure Certification requires Abbott to monitor the volume of leachate removed from the collection system on a monthly basis and submit monitoring results annually. When the average leachate volume generated from the collection system is less than 458.4 gal/day for a 12-month period, Abbott may petition to discontinue the monitoring program and abandon the leachate collection system.

In a 20 November 2002 letter to KDHE, Abbott reported that recent leachate volumes had met the leachate collection system closure conditions and requested that the leachate collection system be abandoned. KDHE denied this request on the basis that the observed decrease in



leachate generation was attributable to drought conditions and did not indicate that the final cover was successfully limiting leachate generation.

In a 17 September 2003 letter from KDHE to Abbott, the agency provided options for corrective measures of the former lagoon. At this juncture Abbott opted for option two which allowed them to discontinue the leachate collection system in combination with the construction of an enhanced cap to improve site drainage and minimize leachate generation and enhance the groundwater monitoring system.

To prevent future precipitation infiltration, the cap required redesign and construction. Abbott used KDHE regulations pertaining to municipal solid waste landfill standards (K.A.R. 28-290-121) as a guideline for the lagoon cover redesign. The redesign and construction provided final slopes which support vegetation and minimize erosion. All slopes were designed to drain runoff away from the cover and prevent ponding. In addition, the cap design minimizes percolation through the cap.

The enhanced low permeability and graded cap was designed for near zero discharge so the existing leachate collection system will not be needed and will be abandoned once the system is drained, the performance standard is met and KDHE approves the abandonment of this system. At that time Abbott will cease operation of the deep injection well since no leachate effluent management will be required. Abbott will also monitor the groundwater quality directly downgradient of the former lagoon as described in this a Groundwater Sampling and Analysis Plan currently being developed through discussions with Abbott, KDHE and U.S.EPA.

Abbott proposes that the term of the monitoring and maintenance be the later of the approved term of the Groundwater Sampling and Analysis Plan that is currently being developed and the decommissioning of the leachate collection and removal system.

## SECTION 3

### OPERATION AND MAINTENANCE PLAN

The planned operation and maintenance activities include the following activities:

- Groundwater monitoring and groundwater monitoring system maintenance.
- Cap and cover monitoring and maintenance.
- Drainage system maintenance.
- Leachate sump monitoring and maintenance.
- Site Security.

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#### 3.1 Groundwater Monitoring

Abbott is currently working with KDHE and U.S.EPA to develop a Groundwater Sampling and Analysis Plan that will identify the wells to be monitored, the chemical constituents that will be analyzed, the frequency and term of the sampling. Abbott will adhere to this plan once it has been agreed upon by all parties.

Abbott will inspect all aspects of the groundwater monitoring system and maintain and repair the system as necessary to keep it functioning and able to be used for the collection of groundwater samples as per the sampling and analysis plan that is currently being negotiated.

Abbott will supply the labor and equipment necessary to carry out all of the tasks related to groundwater monitoring.

### **3.2 Cap and Cover Monitoring and Maintenance**

Abbott will maintain the integrity of the cap and cover system at the site. This will include repairing the soil cover if it erodes or otherwise is damaged and repairing the synthetic liner if it is breached or damaged. It also includes reseeding of the cap if cover repairs are made and in other areas where the vegetation has died or not otherwise grown is sufficient density to prevent erosion or deterioration of the cap and cover system from occurring.

Landscape maintenance will also take place under this task. This primarily consists of mowing the grass which will generally take place two to four times per year, depending on the growth of the vegetation. This is done to discourage the growth of woody plants whose roots may have the capability of penetrating the soil cap and impacting the cover system.

### **3.3 Drainage System Maintenance**

Abbott will maintain the surface drainage system that was constructed at the toe of the cap and cover system. The purpose of this drainage system is to manage runoff from the cap and cover system and to maintain positive drainage off the site in order to minimize infiltration into the cap and cover system. This maintenance will include any needed repair of the swales and/or the removal of any trash or vegetative materials that might accumulate in the drainage swales.

### **3-4 Leachate Sump Monitoring and Maintenance**

Abbott will continue to monitor and maintain the leachate sump until KDHE and Abbott agree to deactivate this system. Monitoring will consist of the periodic inspection to determine if there is leachate accumulation in the sump and whether it needs to be removed and disposed in an appropriate manner. The removal and disposal of the leachate should be all that is involved in the maintenance until the sump is decommissioned.

When the sump is decommissioned, all lines feeding the sump will be sealed with blind flange or the equivalent.

### 3-5 Site Security

The site is currently fenced with personnel and equipment access through locked gates. Abbott will maintain the fence and keep the gates locked during this period of monitoring and maintenance.

DRAFT

ATT-2

# PRE-INVESTIGATION EVALUATION REPORT

ABBOTT LABORATORIES, INC.  
WICHITA, KANSAS FACILITY

October 11, 1990

PREPARED FOR:

ABBOTT LABORATORIES  
1400 SHERIDAN ROAD  
NORTH CHICAGO, ILLINOIS 60604

PREPARED BY:

WOODWARD-CLYDE CONSULTANTS  
5055 ANTIOCH ROAD  
OVERLAND PARK, KANSAS 66203  
913/432-4242

PROJECT NO. 90C7040

the Facility. Acrylonitrile, aniline, and pyridine are probably more amendable to ozone oxidation because of double bonds in their molecular structures, compared to cyclohexyl amines.

#### 3.2.6.2.3 Activated Carbon Adsorption

Benzene and acrylonitrile can be removed from ground water by adsorption using activated carbon. Adsorption data for these compounds in laboratory, pilot and full-scale systems are available in the literature. However, carbon adsorption data for amines are not currently available. Amines are generally water soluble, and so they would not be expected to be readily adsorbed to activated carbon. In the absence of carbon adsorption data on all constituents of concern, it is difficult to determine if activated carbon adsorption would be an effective process for the Facility.

#### 3.2.6.2.4 Biological Treatment

Based on a preliminary literature review conducted by Prof. R. Bartha of Rutgers University (Bartha, 1980) all the organic amines found in ground water at the Facility are biodegradable. The biodegradation seems to be enhanced in acclimated systems. During the biodegradation of organic amines, carbon is oxidized to carbon dioxide and the organic nitrogen portion is hydrolyzed to ammonia. Ammonia may be biologically converted to nitrates in a process called nitrification. The degree of nitrification achieved in biological systems depends on several factors including presence of nitrifying microorganisms and proper environmental and operational conditions.

Biological treatment is a well-established process, and is normally accomplished in suspended (e.g., activated sludge) or attached (e.g., trickling filter) growth reactors. Typically these processes are used for relatively high strength wastes. The ground water at the Facility has shown TOC levels of less than 50 mg/L in most samples collected to date. Reactors to treat such low TOC wastes, referred to as "oligotrophic" reactors, have been used in recent years.

## 6.0 REFERENCES

Bartha, R., 1980. "Biodegradation of Organic Amines." Memo to F. C. Becker (Abbott Laboratories), Rutgers University. February 19.

KDHE, 1988. "RCRA Facility Assessment, Abbott Laboratories, Wichita, Kansas." Kansas Department of Health and Environment, April.

US Environmental Protection Agency, 1988. WERL Treatability Database. USEPA, Washington, D.C.

US Environmental Protection Agency, 1989. "Corrective Action: Technologies and Applications, Seminar Publication." USEPA Report No. 6254-89020.

Woodward-Clyde Consultants, 1990. "Current Conditions Report: Abbott Laboratories, Inc., Wichita, Kansas Facility." October 11, 1990.



(ADJ)

■ ■ ■ ■ ■ ■ ■ ■ RCRA FACILITY  
INVESTIGATION  
ABBOTT  
LABORATORIES  
WICHITA, KANSAS

Prepared for  
U.S. Environmental  
Protection Agency  
Kansas City, Kansas 66101  
and  
Kansas Department of  
Health and Environment  
Forbes Field  
Topeka, Kansas 66620-0001  
April 1992

Woodward-Clyde Consultants  
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Overland Park, Kansas 66203-0777

Project Number 90C7040

## CONTAMINATION FATE AND TRANSPORT

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The previous sections of this report have discussed contaminant source areas and described chemicals associated with past disposal activities at the Facility. The results of chemical analyses of environmental samples have also been presented. The previous studies have identified two major groups of chemicals in soil and groundwater samples from the Facility:

- Amine compounds; and
- Volatile organic compounds.

An essential part of characterizing the potential migration of chemical releases involves understanding the physicochemical properties of the compounds identified at the Facility. The properties of the chemical contaminants combined with environmental fate and transport process are significant factors governing the potential migration of contaminants.

Section 6.1 and 6.2 describe key environmental fate processes and also discuss the physicochemical properties of the most prevalent contaminants identified at the Facility. Because site-specific factors such as geology and hydrogeology are not considered in these two sections, this information alone is insufficient for understanding the potential migration of contaminants at the Abbott site. The information presented is intended to provide general background on those factors that may affect contaminant mobility and predicting potential releases into various environmental media. Section 6.3 integrates the information presented in Sections 6.1 and 6.2 with Facility-specific data which address important migration routes.

### 6.1 POTENTIAL ENVIRONMENTAL FATE PROCESSES

As stated, the potential for a chemical to be released to the environment and its subsequent environmental fate is partially influenced by several chemical and physical

processes. The key environmental processes affecting contaminant releases are summarized in Table 13. However, other environmental processes affect the degradation or movement of contaminants between various environmental media (i.e., air, water, and soil). The mechanisms are summarized in Table 14.

In addition to environmental processes, various physicochemical and biological processes also serve to influence the mobility and chemical fate of contaminants. These processes specifically relate to interactions between contaminants and environmental matrices (i.e., soils). Table 15 presents a summary of these processes.

Sections 6.1 and 6.2 as well as Tables 13 through 15 present preliminary information while Section 6.3 specifically discusses the potential mobilities and environmental fates of the contaminants identified at the Facility. The objective of Section 6.3 is to establish a relationship between potential contaminant mobility at the sites and the results of soil and groundwater analyses. This relationship is important in defining the Facility-specific potential for off-site contaminant migration.

## **6.2 GENERAL PHYSICOCHEMICAL PROPERTIES OF AMINES, AND VOLATILE ORGANIC CHEMICALS**

This section presents a summary of the physicochemical properties of the three classes of chemicals identified at the site. A discussion of how these properties affect the persistence and potential mobility of each class of chemical is also provided. Specific examples of the amine compounds, and VOCs have been selected to illustrate the general fate and transport characteristics of each chemical class. The chemicals selected in this section represent the more prevalent compounds detected in groundwater at the Facility.

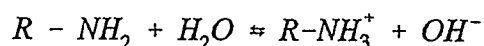
### **6.2.1 Amines**

The results of groundwater analyses, as presented previously, have indicated the presence of various amine compounds known to have been manufactured by Abbott Laboratories. The presence of the amines in the groundwater are related to past on-site waste disposal activities.

Nitrogen, because of its atomic structure, may form three covalent bonds. When three hydrogen atoms participate in covalent bonds with nitrogen, the resulting molecule is ammonia,  $\text{NH}_3$ . Derivatives of ammonia form when one or more of the hydrogen atoms are replaced with various organic groups. These derivatives are called amines.

The amines are divided into three major groups (primary, secondary, and tertiary) based on the number of hydrogen atoms replaced by an organic group(s). Drawing 25 presents the general structure of some of the amine compounds detected at the Facility.

Amines, in general, act as a base or proton acceptors according to the equation presented below:



The reason for this basicity is that in ammonia and the amines, there is a pair of unshared electrons not involved in covalent bonding. This electron pair, however, can be phased with a proton or a hydrogen ion. The electron loan pair on the nitrogen atom of the amines make the molecule polar, which explains why amines are soluble in water and act as bases.

Two factors affect the solubility of amines in water: molecular weight and the degree of substitution. The primary amines are generally more soluble in water, followed by secondary, then tertiary amines.

The solubility and the ionic nature of the amine compounds are important factors in evaluating fate and transport of amines related into the environment. Table 16 presents the chemical and physical characteristics of the Abbott constituents. The information presented in Table 16 also indicates that the higher molecular weight amines are less soluble than lower weight amines. The less soluble nature of a given compound reduces that compound's propensity for movement in the aqueous phase. Those organic amines not soluble in water are, however, soluble in alcohol or other organic solvents.

The following section presents the environmental fate and transport of several of the amine contaminants of concern found at the Facility. These amine compounds are presented by structural group; primary, secondary, and tertiary amines. Within these groups, certain compounds are highlighted due to the available information about their chemical/physical characteristics and their environmental fate and transport (shown in Drawing 26). For those compounds with little available information, generalizations are made.

#### 6.2.1.1 Primary Amines

Primary amines consist of an ammonia ( $\text{NH}_3$ ) molecule where one of the hydrogen atoms is replaced by an organic group. The organic group could be a methyl group ( $\text{CH}_3$ ), an aromatic benzene ring, or an even more complex molecule. The primary amines found in a significant number of wells at the Facility include:

- Aniline;
- Cyclohexylamine; and
- O-Toluidine.

The structures for these compounds as well as those secondary and tertiary amines found through the sampling activities are shown in Drawing 26.

All three of these compounds have a six carbon ring structure bound to the nitrogen as the organic molecule. The difference between the three amines is that the cyclohexyl group is aliphatic in nature while the ring attached to aniline and O-toluidine is fully aromatic or has a resonance structure. O-toluidine has an additional methyl group bound to the benzene ring.

The molecular structure influences the solubility of these compounds (see Table 16). All three of these compounds are relatively soluble in water and, therefore, possess a degree of mobility in the aqueous phase. The solubility of these compounds also aid in their availability for biodegradation. Aniline and cyclohexylamine are known to readily degrade in soil, sediments, and water.

The vapor pressure of these compounds indicates that, if they were released onto surface soil or into surface water, cyclohexylamine would be subject to some vaporization, while aniline and O-toluidine would be less volatile. However, exposure to the atmosphere would result in photo oxidation as the result of interaction with ultraviolet radiation, ozone, and with other atmospheric radicals.

Aniline exhibits a low to moderate sorption to soils with the sorption being stronger at lower Ph. Aniline forms covalent bonds with organic material in soil, such as, humic acids and also is sorbed to clay minerals. Cyclohexylamine is not known to be adsorbed to soil materials and the sorption of O-toluidine to soil materials is also not known.

#### 6.2.1.2 Secondary Amines

The secondary amine compounds have two of the three hydrogen atoms replaced by organic molecules. The secondary amines found at the Facility are:

- Piperidine;
- Dicyclohexylamine; and
- N-Methylcyclohexylamine.

The water solubilities of the secondary amines range from miscible for piperidine to slightly soluble for the other two compounds. Thus, in the presence of water, all three compounds exhibit some ability to dissolve in the aqueous phase, to varying degrees, and therefore be mobile. In water, at a neutral pH, piperidine quickly protonates into its ionic form.

Piperidine is known to be biodegradable in soil and water environments. Dicyclohexylamine and N-methyl cyclohexylamine are also expected to biodegrade, but to a lesser degree than piperidine. Adsorption of piperidine to soil particles is not thought to be a significant process and, therefore, piperidine should not be retained in soils. The adsorption characteristics of the other two compounds are assumed to be similar especially because of the readily dissociated nature of these compounds under neutral conditions.

Of the three secondary amine compounds present, piperidine also has the highest vapor pressure and thus, may volatilize. If released to the atmosphere, the degradation of secondary amines would be similar to the primary amines.

#### 6.2.1.3 Tertiary Amines

The tertiary amines, as shown in Drawing 26, represent some of the more complex amine structures found at the Facility. The compounds included as tertiary amines are:

- N-methyldicyclohexylamine;
- N,N-dimethylcyclohexylamine;
- Pentamethyldipropylenetriamine; and
- 3(N,N-dimethylamino)propynitrile.

The compounds generally have higher molecular weights than the other amine compounds, which contributes to the overall insolubility of these compounds into water. These compounds are, however, more basic in nature than the primary and secondary amines. Thus, pH strongly influences solubility, ionization, and mobility in the aqueous environment.

As a group, the tertiary amines have relatively low vapor pressure and thus, vaporization, when released to the environment, is correspondingly low.

The adsorption potential of the tertiary amines and their interaction with the soil particles are not widely known and thus the fate of the tertiary amines in soils or groundwater is not known.

#### 6.2.2 Volatile Organic Compounds

The waste source characterization performed as part of the RFI field activities did not indicate the presence of volatile organic chemicals (VOCs) in the pond shallow waste source characterization samples or the lagoon leachate samples. Because of these



### 6.3.2 Fate and Transport in Groundwater

The mechanisms that influence the movement of the chemicals of concern are infiltration of precipitation and the percolation of the infiltrated rainwater down to the groundwater zone. The percolation of water through the soil is dependent upon several factors including the characteristics of the soil material (porosity, permeability, and classification) and the groundwater flow regime. Groundwater flow gradients, hydraulic conductivity, and transmissivity, together with mechanisms of attenuation and dispersion, will affect the movement and concentrations of the chemicals of concern.

The chemical characteristics of the chemicals of concern at the Abbott Facility have previously been discussed. A majority of the compounds, amines, and volatile organic compounds are soluble in water to varying degrees. Those compounds most readily soluble would generally be the most mobile and are those that leave the area of release first. These mobile compounds would then generally be the first to disappear over time. The movement of the remaining compounds would then essentially be related to the solubility. Those more soluble compounds would be carried farther than the slightly soluble compounds. The movement of water through soil occurs initially as a result of gravity pulling the meteoric water down through the larger soil openings while the smaller soil pores take in water as a result capillary forces. The further downward movement ultimately depends upon the geologic characteristics underlying the Facility such as hydraulic gradient, porosity, permeability, and pore size. Movement of water through the subsurface may be accelerated through cracks, fractures, or layers of more porous soils that act as hydraulic conduits.

#### 6.3.2.1 Amines

The subsurface soils present at the Abbott Facility, for the most part, allow for the rapid infiltration of meteoric water in areas that are not paved or capped. The downward percolation results in contact with the waste materials. The chemical characteristics of the water, in particular pH, determine its ability to accumulate the chemical constituents that may be present. The amines, the main constituents of the former Facility's waste, are soluble to varying degrees from very soluble to slightly soluble. The pH of the percolating water as well as the concentration gradient and temperature will also

influence the solubility as a result of the chemical nature of the amine compounds. The amines are slowly moved from the area of deposit into groundwater regime. The distribution throughout the groundwater system, vertical and lateral distribution, is a function of many factors including time, temperature, and the hydrogeological parameters of the area, most importantly hydraulic gradients.

#### **6.3.2.2 Volatile Organic Compounds**

The volatile organic compounds found at the Abbott Facility, including both aromatics and chlorinated compounds, have water solubilities that indicate their ability to go readily into solution. The mobility of the compounds, once they are in solution, depends on the hydrogeologic factors. The relative stability of the volatile organic compounds once they are in the groundwater system is the result of the relative reduced environment (where the environmental has little oxygen present or air-liquid interface that may encourage volatilization or degradation. Thus, once in the groundwater system the migration of the organic compounds will depend on the geologic, chemical, and hydrogeologic properties of the area.

#### **6.3.3 Fate and Transport in Surface Water**

Surface water surrounding the Facility is primarily found in draws, drainage ditches, and intermittent streams north and south of the Facility. Surface water generally is the result of surface runoff. The surrounding topography is relatively flat. High evapotranspiration rates of the area also influences the surface water found around the Facility, and the result is very few surface water bodies.

The transport of the chemicals of concern from the Facility to the few surface water bodies surrounding the site is estimated to be minor. The primary contaminants were discharged as waste to the former ponds and lagoons, and thus were not released to the surface environment. However, if released to the surface, the volatile organic compounds generally have high vapor pressures and volatilize readily, whereas the amines will volatilize to a lesser degree. The chemicals of concern are also characterized by their general biodegradable nature and their mobility as has been previously

TABLE 16

PHYSICAL AND CHEMICAL PARAMETERS OF SELECTED  
ORGANIC COMPOUNDS FOUND AT  
ABBOTT LABORATORIES, WICHITA, KANSAS

Compound	Molecular Weight <sup>2</sup>	CAS No. <sup>1</sup>	Density <sup>1</sup>	Vapor Pressure	Vapor Density <sup>4</sup>	Water Solubility	K <sub>OC</sub> <sup>5</sup>	Log K <sub>ow</sub>	Melting Point°C <sup>1</sup>	Boiling Point°C <sup>1</sup>
Benzene, C <sub>6</sub> H <sub>12</sub>	78.1	71-43-2	0.8790	76 mm @ 20°C <sup>4</sup>	2.77	0.7% <sup>3</sup>	31.7-143	2.13 (20) <sup>4</sup>	5.5	80.1
Methylene Chloride, CH <sub>2</sub> Cl <sub>2</sub>	84.9	75-09-2	1.335 (15/4)	349 mm @ 20°C <sup>4</sup>	2.93	2% <sup>3</sup>	1.68	1.25 <sup>5</sup>	-97 <sup>1</sup>	40.1
Tetrachloroethylene, C <sub>2</sub> Cl <sub>4</sub>	165.8	127-18-4	1.625 (20/20C)	14 mm @ 20°C <sup>4</sup>	5.83	0.02% (77°) <sup>3</sup>	209	2.60 (20)	-22.4	121
Tetrachloromethane (carbon tetrachloride), CCl <sub>4</sub>	153.8	56-23-5	1.585 (25/4C)	91.3 mm @ 20°C <sup>1</sup>	5.5	0.05% <sup>3</sup>	110	2.64 (20) <sup>4</sup>	-23.0	76.7
Toluene, C <sub>7</sub> H <sub>8</sub>	92.1	108-88-3	0.866 (20/4C)	22 mm @ 20°C <sup>4</sup>	3.14	0.067% <sup>1</sup> (23.5°C)	37-178	2.69 (20)	-94.5	110.7
1,1,1-Trichloroethane, C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>	133.4	71-55-6	1.325	10 mm @ 20°C <sup>4</sup>	4.63	Insoluble <sup>1</sup>	183	2.49 <sup>5</sup>	-38	75
Trichloroethylene, C <sub>2</sub> HCl <sub>3</sub>	131.4	79-01-6	1.456-1.462 (25/25C)	60 mm @ 20°C <sup>4</sup>	4.54	0.1% @ 77°F <sup>3</sup>	87, 150	2.42 <sup>5</sup>	-73	86.7
Trichloromethane (Chloroform), CHCl <sub>3</sub>	119.4	67-66-3	1.485 (20/20C)	160 mm @ 20°C <sup>4</sup>	4.12	0.5% @ 77°F <sup>3</sup>	34 <sup>1</sup>	1.97 (20) <sup>4</sup>	-63.5	61.2
Vinyl Chloride, C <sub>2</sub> H <sub>3</sub> Cl	62.5	75-01-4	0.9121 (20/20C)	2300 mm @ 20°C <sup>1</sup>	2.15	0.1% @ 77°F <sup>3</sup>	0.40, 56	1.38 <sup>5</sup>	-159.7	-13.9
1,1-Dichloroethane, C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	98.9	75-34-3	1.174	180 mm @ 20°C <sup>4</sup>	3.42	0.6% <sup>3</sup>	40	1.79 <sup>5</sup>	-98	57-59
1,2-Dichloroethane, C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	98.9	107-06-2	1.2554 (20/14C)			Insoluble <sup>1</sup>	33,152	1.48 <sup>5</sup>	-35.5	83.5
Ethylbenzene, C <sub>8</sub> H <sub>10</sub>	106.1	100-41-4	0.867 (20)	7 mm @ 20°C <sup>4</sup>		0.01% <sup>3</sup>	164	3.15 <sup>4</sup>	-95	136.79
Xylenes, C <sub>8</sub> H <sub>10</sub>	106.1	1330-20-7	~ 0.86	5 mm @ 20°C <sup>4,6</sup>	3.7 <sup>6</sup>	Insoluble <sup>3</sup>	48-68 <sup>6</sup>	2.77 <sup>4,7</sup>	-25, -13.2	138.5-144
Cyclohexylamine, C <sub>6</sub> H <sub>13</sub> N	99.17 <sup>2</sup>	108-91-8	0.8191 <sup>2</sup>	15 mm @ 30°C	3.42 <sup>2</sup>	Completely Miscible <sup>1</sup> W/H <sub>2</sub> O	~ 154 <sup>4</sup>	1.49	-17.7 <sup>1</sup>	134.5 <sup>10</sup>
Dicyclohexylamine, C <sub>12</sub> H <sub>23</sub> N	181.3	101-83-7	0.9123	0.23 psi @ 100°F		Slightly in hot H <sub>2</sub> O			-0.10	255.8
N(3-aminopropyl)cyclohexylamine, C <sub>9</sub> H <sub>20</sub> N <sub>2</sub>	156.2	3312-60-5	0.91	10 mm @ 230°C		Slightly				234

TABLE 16  
(Continued)  
PHYSICAL AND CHEMICAL PARAMETERS OF SELECTED  
ORGANIC COMPOUNDS FOUND AT  
ABBOTT LABORATORIES, WICHITA, KANSAS

Compound	Molecular Weight <sup>2</sup>	CAS No. <sup>1</sup>	Density <sup>1</sup>	Vapor Pressure	Vapor Density <sup>4</sup>	Water Solubility	K <sub>OC</sub> <sup>5</sup>	Log K <sub>ow</sub>	Melting Point°C <sup>1</sup>	Boiling Point°C <sup>1</sup>
N,N-dimethylcyclohexylamine, C <sub>8</sub> H <sub>17</sub> N	127.2	98-94-2	0.8512	0.19 psi @ 100°F	4.38	Insoluble				159 @ 756 mm/kg
N-methyldicyclohexylamine, C <sub>13</sub> H <sub>25</sub> N	195.35	7560-83-0	0.92	0.22 psi @ 100°F	6.73	Insoluble				265
N-Methylcyclohexylamine, C <sub>7</sub> H <sub>16</sub> N	113.2	100-60-7	0.8660	11 mm @ 40°C		Slightly				149
Pentamethyldipropylenetriamine, C <sub>11</sub> H <sub>27</sub> N <sub>3</sub>	201.3									
Aniline, C <sub>6</sub> H <sub>7</sub> N	93.1 <sup>2</sup>	62-53-3	1.021 <sup>2</sup>	0.3 mm <sup>2</sup> @ 20°C	3.22 <sup>2</sup>	34,000 mg/l <sup>2</sup>		0.90/0.98 <sup>2</sup>	-6 <sup>2</sup>	184 <sup>2</sup>
O-toluidine, C <sub>7</sub> H <sub>9</sub> N	107.1 <sup>1</sup>	95-53-4	1.004 <sup>1,2</sup>	0.26 mm @ 25°C	3.72 <sup>2</sup>	15,000 mg @ 25°C		1.29/1.32 <sup>2</sup>	α-24.4 β--16	200 <sup>2</sup>
Pyridine, C <sub>5</sub> H <sub>5</sub> N	79.1 <sup>2</sup>	110-86-1	0.982	20 mm <sup>2</sup> @ 25°C	2.73 <sup>2</sup>	Miscible	7/20 <sup>6</sup>	0.64/1.04 <sup>2</sup>	-42 <sup>2</sup>	115 <sup>2</sup>
Piperidine, C <sub>5</sub> H <sub>11</sub> N	85.15 <sup>1</sup>	110-89-4	0.8622 <sup>1</sup>	40 mm @ 29°C	2.94	High	7/20 <sup>6</sup>	0.64/1.04 <sup>2</sup>	-70 <sup>1</sup>	106 <sup>1</sup>
2,5-dimethylpyrazine, C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>	108.14		0.99		3.72	Infinite				182
3(N,N-dimethyl amino)propyl nitrile, C <sub>5</sub> H <sub>10</sub> N <sub>2</sub>	98	123-33-20	0.86		3.35					170
Acrylonitrile, C <sub>3</sub> H <sub>3</sub> N	53.06 <sup>5</sup>	107-13-1 <sup>5</sup>	0.80 <sup>4</sup>	100 mm <sup>2</sup>	1.83 <sup>2</sup>	75,000 mg/l <sup>5</sup>		0.92	-82 <sup>4</sup>	77 <sup>4</sup>

Notes:

- <sup>1</sup> Condensed Chemical Dictionary, 11th Edition.
- <sup>2</sup> Merck Index, 11th Edition, Merck and Company, Inc., 1989.
- <sup>3</sup> NIOSH Pocket Guide to Chemical Hazards, U.S. Department of Health and Human Services, September 1985.
- <sup>4</sup> Verschueren, Karel, "Handbook of Environmental Data on Organic Chemicals," Van Nostrand Reinhold Co., Inc.
- <sup>5</sup> Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume I Large Production and Priority Pollutants, Philip H. Howard, Editor, Lewis Publishers, 1990.
- <sup>6</sup> Toxicological Profile for Pyridine, Draft, U.S. Department of Health and Human Services, October 1990.
- <sup>7</sup> Values given are for o-xylene.

■ ■ ■ ■ ■ RCRA FACILITY  
INVESTIGATION  
ABBOTT  
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## 2.5 SURFACE WATER USE SURVEY

A surface water use survey was conducted to identify and characterize the surface water bodies within a one square-mile radius of the Facility. The RFI Work Plan scope of work for the surface water survey included the following tasks:

- Identification of surface water features, both natural and man-made;
- Identification of runoff patterns from the Facility; and
- A visual assessment of sediments for contamination from off-site surface water runoff.

Surface water features and runoff patterns were identified using maps (USGS topographical) and aerial photographs of the Facility area. This information was verified during the RFI field investigation, including a reconnaissance of the area adjacent to and surrounding the Facility. Runoff patterns were not assessed during a storm event.

The results of the surface water use survey are summarized in Section 4.2.3.

## 2.6 GROUNDWATER USE SURVEY

A groundwater use survey was conducted within a 1.5 mile radius of the Facility. The purpose of the survey was to assess the impacts, if any, that man-made influences have on the hydrogeology of the area. The survey included the following items.

- A review of state and county records;
- An identification of groundwater uses (residential and commercial) and pumpage schedules; and
- A field reconnaissance to locate wells and features that may affect the hydrogeology, such as ditches, buried pipelines, drains, and outfalls.

The review of well records and identification of groundwater uses was completed in conjunction with other RFI activities. The results of the groundwater use survey are summarized in Section 4.1.1.5.



The gradients recorded by Lane and Miller (1965) are similar to those measured recently, but the groundwater levels reported by Lane and Miller are about 15 feet lower than levels recorded at present. This may be a function of local groundwater use and natural fluctuations. Lane and Miller, while studying the natural fluctuations around the Wichita well field north of the Arkansas River, found water level fluctuations occurring from the natural conditions of recharge and discharge through a climatic cycle to be about 8 feet (Lane and Miller, 1965). Data presented by the Kansas Geological Survey suggest that water levels for the area have remained relatively unchanged for the last 30 years (Buddemeier et al, 1991).

There is considerable pumping occurring around the Facility for irrigation, process water, and ongoing groundwater remediation. Drawing 24 shows the wells located within a one and a half-mile radius of the Facility and Table 10 lists the individual well withdrawals. These data were obtained from permit records, well inventory databases, and interviews with farmers and local industries. The Air Products well No. 15 and Abbott extraction wells EW-10 and EW-17 are sufficiently close to the Facility to directly affect the water levels, as indicated by the field measurements. In addition, the abundance of regional high capacity irrigation wells is sufficient to produce a regional lowering of the water table. This lowering however, does not seriously effect the shape of the water level contours directly under the Facility. The direction of flow remains in an east to southeasterly direction.

#### **4.1.1.5 Man-Made Influences Affecting Hydrogeology**

##### **Local Water Supply Wells**

A total of 68 wells have been identified within one and a half mile radius of the Facility. The main sources of information for well identification include the Kansas Department of Health and Environment and the Kansas Board of Agriculture. Ground water is mainly used for industrial, agricultural, and domestic purposes in the Facility vicinity. Drawing 24 indicates the location of water supply wells and Table 10 provides a summary of information concerning well ownership, ground water use, and other well parameters.

Use of ground water for industrial purposes represents a steady demand for the aquifer. Crop irrigation is more an intermittent activity and water use peaks during the irrigation of cultivated land neighboring the Facility. The effect of irrigation on ground water levels can be observed on the hydrographs generated from data logger information for monitoring wells close to the Facility (see Appendix F).

There are other well categories, such as domestic lawn and garden, oil field water supply, dewatering, and air conditioning. Water demand from these wells is small and usually intermittent. Therefore, their impact on ground water levels is considered minimal.

Two irrigation wells, owned by Mr. Bergkamp, are located between 6,000 and 7,000 feet northwest of the Facility. Air Products owns a small irrigation well. Water from this well is used for lawn irrigation. Thirteen industrial wells were identified within the survey area. These industrial wells are owned by Vulcan Chemicals, Air Products, and Abbott Laboratories.

The two Abbott extraction wells, EW-10 and EW-17, are the closest wells to the Facility, located approximately 500 feet north and 300 feet east-northeast, respectively of the closed pond. Extraction well EW-10 is screened in the S-2 sand unit. Extraction well EW-17 is screened in parts of both the S-2 and S-1 sand units.

### Pumping Rates

Well pumping rates can be categorized by well use and operation. Generally, irrigation wells are operated at high rate for short periods of time. Industrial wells are operated at lower rates and continuously throughout the year. Domestic wells are operated at very low rates and periodically. Table 11 presents the average pumping yield of industrial and irrigation wells operated during 1989, which is the latest period for which pumping data were available.

The two major irrigation wells owned by Mr. Bergkamp pumped intermittently at rates of approximately 800 to 900 gallons per minute (gpm) each during the 1989 irrigation season. Air Products owns a small irrigation well which yields approximately 30 gpm

TABLE 10

## PUMPED WELLS WITHIN A 1.5-MILE RADIUS FROM THE ABBOTT SITE

Well ID Number <sup>1</sup>	Well Owner	Water Use	Well Depth (ft.)	Well Status	Approximate Well Distance from Abbott Site (ft.)	Well Pumpage Yield <sup>2</sup> (GPM)	Well Drilled Date
2801W280003	Bergkamp	Irrigation	135	active	6900	800	04/22/86
2801W280004	Bergkamp	Irrigation	130	active	6200	900	04/24/86
2801W280001	Unknown	Oil Field W.S.	107	active	5140	40	10/30/75
2801W280002	Unknown	Irrigation	127	active	7240	--	07/17/81
2801W260006	Unkown	Domestic	50	active	7900	--	06/29/77
2801W270004	Unknown	Industrial	59	active	5840	50	10/12/77
2801W270005	Unknown	Other	106	active	6900	--	09/28/83
2801W270037	Builders Const.	Lawn and Garden	90	active	6800	--	06/08/89
2801W270002	Vulcan	Industrial	111	active	4800	20	08/16/77
2801W270003	Vulcan	Industrial	87	active	4700	20	10/06/77
2801W270008	Vulcan	Industrial	101	active	3940	495	10/14/77
2801W270013	Vulcan	Industrial	110	active	2600	69 <sup>4</sup>	10/13/77
2801W270036	Colley	Lawn and Garden	35	active	2600	--	04/21/89
2801W270009	Vulcan	Industrial	74	active	3000	44 <sup>4</sup>	10/14/77
2801W270010	Vulcan	Other	61	active	2800	--	06/28/83
2801W270012	Vulcan	Industrial	79	active	3240	43 <sup>4</sup>	10/11/77
2801W270033	Vulcan	Other	77	active	3200	--	04/04/86

## Notes:

<sup>1</sup> Well ID number taken from the KDHE official permit number.<sup>2</sup> Well pumpage yield obtained from KDHE water well records. The estimated well pumpage yield is given at the time of permit and does not represent actual operation pumping rates.<sup>3</sup> Well plugged date.<sup>4</sup> Well pumpage yield obtained from Kansas Board of Agriculture water use records for 1989.

TABLE 10  
(Continued)  
PUMPED WELLS WITHIN A 1.5-MILE RADIUS FROM THE ABBOTT SITE

Well ID Number <sup>1</sup>	Well Owner	Water Use	Well Depth (ft.)	Well Status	Approximate Well Distance from Abbott Site (ft.)	Well Pumpage Yield <sup>2</sup> (GPM)	Well Drilled Date
2801W270034	Vulcan	Other	76	plugged	3400	--	05/28/87 <sup>3</sup>
2801W270035	Vulcan	Other	74	plugged	3560	--	05/28/87 <sup>3</sup>
2801W270006	Unknown	Industrial	65	active	4300	38	10/06/77
2801W270007	Unknown	Industrial	80	active	4300	32	10/07/77
2801W270011	Vulcan	Industrial	81	active	3600	57 <sup>4</sup>	10/10/77
2801W260002	Unknown	Domestic	55	active	7600	--	02/26/80
2801W260003	Girrens	Lawn and Garden	60	active	7300	--	04/19/84
2801W340005	Unknown	Other	101	active	3800	--	10/05/83
2801W340006	Unknown	Other	70	active	3720	--	10/06/83
2801W340010	Unknown	Other	70	active	2300	--	10/04/83
2801W340011	Unknown	Other	101	active	2500	--	10/03/83
2801W340002	Unknown	Industrial	96	active	800	--	07/27/81
2801W340003	Abbott Labs	Industrial	97	active	800	93 <sup>4</sup>	08/10/83
2801W340001	Cunningham	Domestic	70	active	1640	--	03/08/85
2801W340009	Unknown	Lawn and Garden	50	active	2640	--	09/01/78
2801W350005	Bohannon	Domestic	70	active	5800	30	12/12/84

**Notes:**

- <sup>1</sup> Well ID number taken from the KDHE official permit number.
- <sup>2</sup> Well pumpage yield obtained from KDHE water well records. The estimated well pumpage yield is given at the time of permit and does not represent actual operation pumping rates.
- <sup>3</sup> Well plugged date.
- <sup>4</sup> Well pumpage yield obtained from Kansas Board of Agriculture water use records for 1989.

**TABLE 10**  
(Continued)  
**PUMPED WELLS WITHIN A 1.5-MILE RADIUS FROM THE ABBOTT SITE**

Well ID Number <sup>1</sup>	Well Owner	Water Use	Well Depth (ft.)	Well Status	Approximate Well Distance from Abbott Site (ft.)	Well Pumpage Yield <sup>2</sup> (GPM)	Well Drilled Date
2801W350003	Bohannon	Air Conditioning	70	active	5820	30	12/12/84
2801W350001	Cunningham	Domestic	80	active	5860	28	09/07/85
2801W350004	Unknown	Domestic	65	active	5900	23	08/22/80
2901W020001	Hill	Domestic	80	active	6800	50	05/14/85
2901W030008	McKown	Lawn and Garden	67	active	6400	--	10/26/83
2901W030009	Unknown	Domestic	65	active	6320	--	08/30/79
2901W030024	McKown	Domestic	65	active	6260	--	02/16/89
2901W030011	Unknown	Domestic	65	active	6300	--	03/08/77
2901W030012	Unknown	Domestic	60	active	6260	--	09/30/76
2901W030025	McKown	Domestic	60	active	6060	--	02/21/89
2901W030005	Unknown	Domestic	100	active	5260	--	04/13/77
2901W030006	Unknown	Domestic	60	active	6000	--	04/13/77
2901W030007	Unknown	Domestic	60	active	5200	--	01/27/76
2901W030001	Caylor	Domestic	120	active	6640	--	11/06/84
2901W030010	Unknown	Lawn and Garden	54	active	4400	--	01/06/84
2901W040006	Kirkstatter	Domestic	115	active	4300	--	07/09/84

**Notes:**

- <sup>1</sup> Well ID number taken from the KDHE official permit number.
- <sup>2</sup> Well pumpage yield obtained from KDHE water well records. The estimated well pumpage yield is given at the time of permit and does not represent actual operation pumping rates.
- <sup>3</sup> Well plugged date.
- <sup>4</sup> Well pumpage yield obtained from Kansas Board of Agriculture water use records for 1989.

TABLE 10  
(Continued)  
PUMPED WELLS WITHIN A 1.5-MILE RADIUS FROM THE ABBOTT SITE

Well ID Number <sup>1</sup>	Well Owner	Water Use	Well Depth (ft.)	Well Status	Approximate Well Distance from Abbott Site (ft.)	Well Pumpage Yield <sup>2</sup> (GPM)	Well Drilled Date
2901W040004	League	Domestic	110	active	5940	30	06/06/84
2901W040009	Anderson	Domestic	115	active	7200	--	10/15/84
2901W040005	Kirk	Domestic	105	active	7400	--	12/11/84
2901W040007	Keaton	Domestic	120	active	7500	--	02/19/85
2901W040016	Gillespie	Domestic	115	active	7000	30	05/19/87
2901W040018	Bishop	Domestic	100	active	7200	--	05/19/88
2901W040002	Unknown	Domestic	66	active	7200	20	04/18/80
2901W040020	Wirth Excavating	Lawn and Garden	45	active	5100	--	02/25/89
2801W330025	Chapman	Domestic	29	active	4500	--	03/12/86
2801W330027	Air Products, Inc.	Oil Field W.S.	95	plugged	3960	--	10/20/86 <sup>3</sup>
2801W330005	Abbott Labs	Other	115	active	800	36 <sup>4</sup>	09/29/83
2801W330006	Air Products, Inc.	Industrial	131	active	2000	100 <sup>4</sup>	04/22/80
2801W330004	Unknown	Domestic	76	active	960	--	11/26/79
2801W330034	Air Products, Inc.	Irrigation	85	active	1060	30	05/11/89
2801W290001	Unknown	Domestic	130	active	5800	--	09/12/79
2801W320003	Clear Water Excavating	Dewatering	47	active	7100	--	04/07/80

Notes:

- <sup>1</sup> Well ID number taken from the KDHE official permit number.
- <sup>2</sup> Well pumpage yield obtained from KDHE water well records. The estimated well pumpage yield is given at the time of permit and does not represent actual operation pumping rates.
- <sup>3</sup> Well plugged date.
- <sup>4</sup> Well pumpage yield obtained from Kansas Board of Agriculture water use records for 1989.

TABLE 10  
(Continued)  
PUMPED WELLS WITHIN A 1.5-MILE RADIUS FROM THE ABBOTT SITE

Well ID Number <sup>1</sup>	Well Owner	Water Use	Well Depth (ft.)	Well Status	Approximate Well Distance from Abbott Site (ft.)	Well Pumpage Yield <sup>2</sup> (GPM)	Well Drilled Date
2801S320004	Clear Water Excavating	Dewatering	48	active	7000	--	03/31/80
2801W320006	Clear Water Excavating	Dewatering	50	active	7240	--	04/18/80
2901W050001	Unknown	Domestic	115	active	7000	--	08/16/80

Notes:

<sup>1</sup> Well ID number taken from the KDHE official permit number.

<sup>2</sup> Well pumpage yield obtained from KDHE water well records. The estimated well pumpage yield is given at the time of permit and does not represent actual operation pumping rates.

<sup>3</sup> Well plugged date.

<sup>4</sup> Well pumpage yield obtained from Kansas Board of Agriculture water use records for 1989.